Project Management for Scientists

Cost & Schedule Estimates

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Outline

- Resource Assignments
- Estimates
- Types of Estimates
- Cost Estimates
- Schedule Estimates
- Task Dependencies
- Scheduling
- Cash Flow Plan

Resource Assignment

- Consider and resolve the following issues:
  - Who and what do we need to make the project a success?
  - Who is actually available?
  - How can we make up the shortfall if resources are not available when needed?
  - Will resource constraints cause schedule slip or cost overrun?

Estimates

- Forecasts or approximations of cost and schedule it takes to produce deliverables
- Needed to
  - determine length and cost of project
  - schedule work ahead of time
  - develop cash flow requirements
  - track progress of project
  - develop baseline plan

Types of Estimates

Accurate estimates require accurate specifications

- Ballpark estimate (gut feeling of an expert)
  - Very fast, easily wrong by factor of 2
  - Only use to decide whether more accurate estimate should be obtained
- Rough Order of Magnitude (ROM)
  - Extrapolation from previous projects
  - Often good enough to start project
- Detailed, bottom-up estimates from WBS

Top-Down Estimates

- Fastest, least precise method
- Divide project into major components, then estimate each component based on previous experience with similar projects
- Adjust for differences between new project and the ones estimate is based on
- Most accurate when estimators have past experience with similar projects and historical data is available

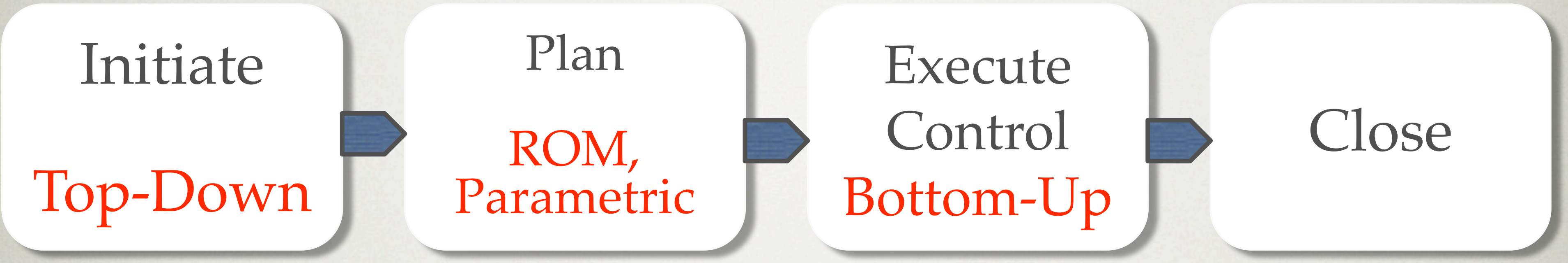
Parametric Estimating

- Uses formula to predict time and cost of future work based on past, completed projects
- Fast if good models and historic data from many projects are available
- Good when estimating something that has been done many times before
- Example: €500 per m^3 for residential house in The Netherlands

Bottom-Up Estimating

- Estimate each work package individually
- Sum up all estimates for the total project estimate
- Requires comprehensive and detailed WBS
- Cannot be used before detailed planning stage of project
- Takes most time, but often most accurate

Phased Estimating



- Estimates can become more accurate as project progresses from definition through planning to execution
- Phased estimating uses different estimating techniques at different
- Works well in scientific projects

Bad Estimates

- "Let's get started", i.e. no or not enough planning
- Fuzzy definition of scope, i.e. fuzzy scope leads to fuzzy estimates
- Unwarranted optimism, i.e. failure to expect and account for problems
- Insufficient historical information

Expense Types

- Direct Costs
  - can be directly linked to specific work package
  - Materials, labor, equipment, contracts
- Overhead
  - Fixed costs spread over the whole project
  - Workplace facilities, training, supervisors, contracting support

Top-Down Cost Estimates

- Project Charter contains cost estimates
- Typical management estimate
- Based on previous experience
- Externally given contract value
- Not very precise
- Not useful for cost tracking
- Mostly constraints (spending limit)

Bottom-Up Cost Estimate

- Add all expense types for each work package (involve people assigned to WP)
- Sum all work package costs to get total project cost
- Add contingency
- Compare with top-down estimate and resolve discrepancies

Contingency

- Estimates are never 100% certain
- Must cover risk of underestimating cost and unforeseen problems
- For scientific project, at least 20% cost contingency for well-defined plan
- Otherwise, 100% during definition, 50% during design, 20% for construction
- May have to be hidden as many funding agencies do not allow inclusion of contingency

Realistic Schedules

- Includes detailed knowledge of work to be done
- Has task sequence in correct order
- Accounts for external constraints beyond control of project team
- Can be accomplished on time given access to skilled people and sufficient equipment

Milestones

- Mark significant events in a project's life
- May be part of WBS
- Milestones take no time, do not influence schedule
- Start and finish of a project may be milestones
- May mark input from one party/phase to another
- May represent significant events that are not represented by summary task or work package
- Show major progress points

Milestones Example

milestone	updated (Sep. 2008)	proposal (May 2007)	passed?
PhD student starts	March 2008	March 2008	yes
Design Review	February 2009	November 2008	
AIT finished	November 2009	July 2009	
Instrument shipped to the USA	January 2010	November 2009	
First light at SOLIS	March 2010	February 2010	
Start of regular data collection at SOLIS	July 2010	June 2010	
Thesis defense PhD student	April 2012	April 2012	
Minimum instrument lifetime achieved	Jun 2020	May 2020	

PERT Analysis

- Program Evaluation and Review Technique (PERT)
- Widely known, rarely used
- 3 Estimates:
  - Optimistic, best case (O)
  - Pessimistic, worst case (P)
  - Most Likely, single estimate outcome (M)
- Most estimates are closer to optimistic than pessimistic
- More realistic estimate: $R = (O+4*M+P)/6$

SCHEDULING

1. Take Work Breakdown Structure
2. Specify the person/vendor who will accomplish each work package/task and ask how much time it takes
3. Establish task dependencies between and among tasks
4. Determine completion dates for each task
5. Add this information and assumptions to plan
6. Create overall schedule

Task Dependencies

For each work package ask

- When could it begin?
- When must it begin?
- When could it finish?
- When must it finish?
- Where does it lead to?
- What would be delayed if it slipped?

Determine Task Dependencies

- Task dependencies only exist between work packages (summary tasks consist of work packages)
- Task dependencies only reflect sequence constraints (A must be done before B)
- Schedules are typically made by assuming that task must be completed before successor task can start

Task Dependency Example

ID		Task Name	WBS	Duration	Predecessors
1		**Polarimeter**	**1**	**87 days**	
2		**Modulator Package**	**1.1**	**82 days**	
3		**FLC**	**1.1.1**	**28 days**	
4		controller	1.1.1.1	1 day	
5		determine center wavelen	1.1.1.2	2 days	
6		requirements	1.1.1.3	3 days	4,5,10
7		quotes	1.1.1.4	1 day	6
8		purchase	1.1.1.5	2 days	7
9		test	1.1.1.6	3 days	8
10		achromatic design	1.1.2	2 days	
11		half-wave plate	1.1.3	1 day	
12		rotation mechanism design	1.1.4	5 days	
13		rotation mechanism manufactu	1.1.5	2 wks	12
14		temperature controller design	1.1.6	5 days	7
15		temperature controller manufa	1.1.7	2 wks	14
16		**Polarization compensator**	**1.2**	**79 days**	
17		specifications	1.2.1	2 days	
18		mechanical design	1.2.2	2 wks	
19		mechanical fabrication	1.2.3	2 wks	18
20		**Polarizing Beamsplitter**	**1.3**	**76 days**	
21		specifications	1.3.1	2 days	
22		optical design	1.3.2	3 days	21
23		purchase beamsplitter	1.3.3	2 days	22
24		purchase prisms	1.3.4	2 days	22
25		mechanical design	1.3.5	1 wk	
26		mechanical fabrication	1.3.6	2 wks	25
27		AIT	1.3.7	1 wk	23,24,26
28		**Polarization calibration**	**1.4**	**60 days**	
29		requirements	1.4.1	3 days	
30		design	1.4.2	2 wks	
31		fabrication	1.4.3	2 wks	30
32		fiber-fed focal plane	1.4.4	1 day	

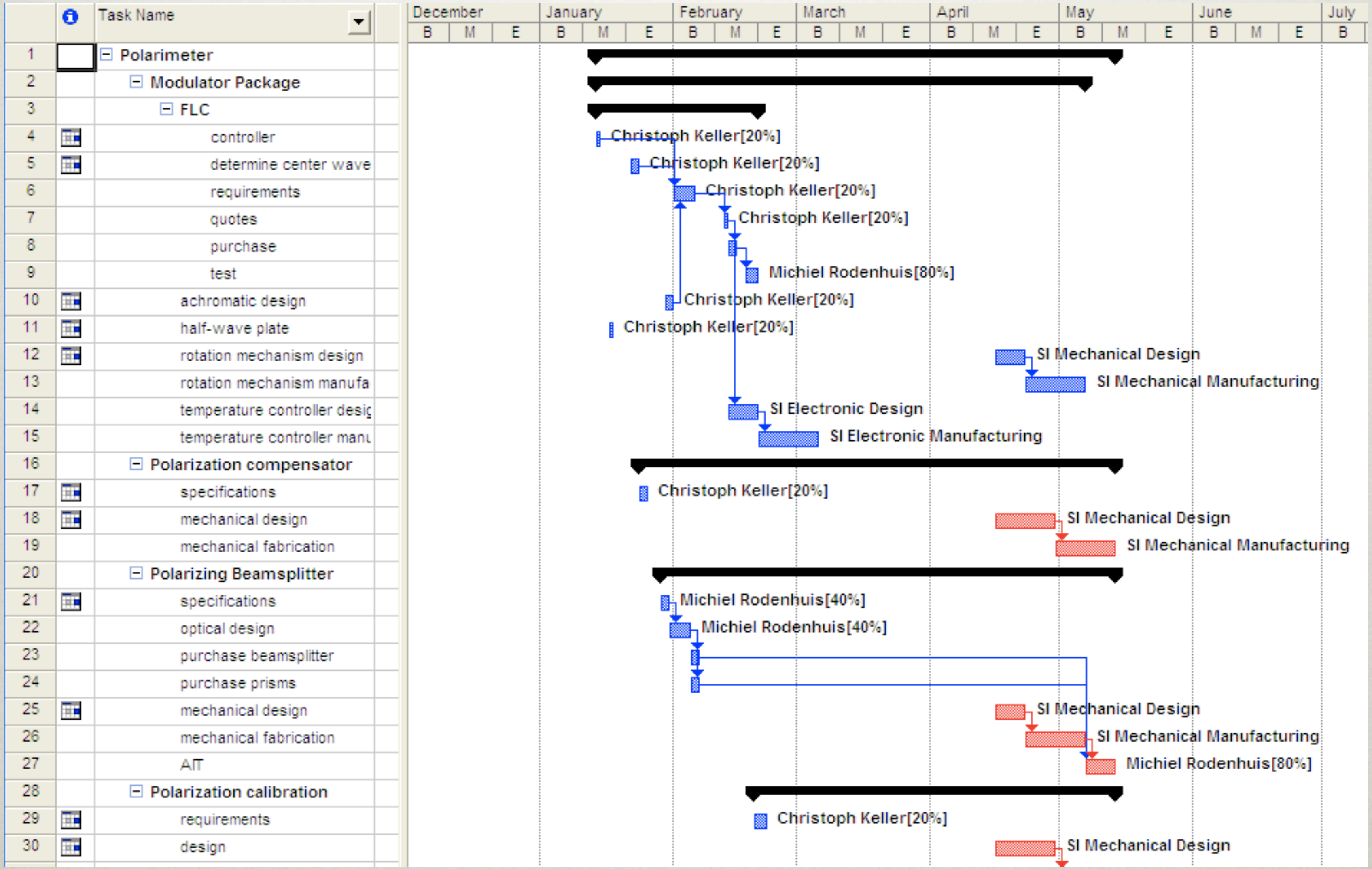
Labor Estimate vs Duration

- People are not available 100% of the time
- People are not 100% efficient
- Decisions can take significant time to get to
- Orders are placed quickly, but delivery can take a long time
- Labor estimate = time it takes somebody working 100% on the task to finish it
- Duration estimate = time that passes on the clock until task is finished

Example Resource Assignment

		Task Name	WBS	Duration	Resource Names	Predecessors
1		**Polarimeter**	**1**	**87 days**	[redacted]	
2		**Modulator Package**	**1.1**	**82 days**		
3		**FLC**	**1.1.1**	**28 days**		
4		controller	1.1.1.1	1 day	Christoph Keller[20%]	
5		determine center wave	1.1.1.2	2 days	Christoph Keller[20%]	
6		requirements	1.1.1.3	3 days	Christoph Keller[20%]	4,5,10
7		quotes	1.1.1.4	1 day	Christoph Keller[20%]	6
8		purchase	1.1.1.5	2 days		7
9		test	1.1.1.6	3 days	Michiel Rodenhuis[80%]	8
10		achromatic design	1.1.2	2 days	Christoph Keller[20%]	
11		half-wave plate	1.1.3	1 day	Christoph Keller[20%]	
12		rotation mechanism design	1.1.4	5 days	SI Mechanical Design	
13		rotation mechanism manufa	1.1.5	2 wks	SI Mechanical Manufacturing	12
14		temperature controller desig	1.1.6	5 days	SI Electronic Design	7
15		temperature controller manu	1.1.7	2 wks	SI Electronic Manufacturing	14
16		**Polarization compensator**	**1.2**	**79 days**		
17		specifications	1.2.1	2 days	Christoph Keller[20%]	
18		mechanical design	1.2.2	2 wks	SI Mechanical Design	
19		mechanical fabrication	1.2.3	2 wks	SI Mechanical Manufacturing	18
20		**Polarizing Beamsplitter**	**1.3**	**76 days**		
21		specifications	1.3.1	2 days	Michiel Rodenhuis[40%]	
22		optical design	1.3.2	3 days	Michiel Rodenhuis[40%]	21
23		purchase beamsplitter	1.3.3	2 days		22
24		purchase prisms	1.3.4	2 days		22

Gantt Chart


Task Name
December
January
February
March
April
May
June
July
1 Polarimeter
2 Modulator Package
3 FLC
4 controller
5 determine center wave
6 requirements
7 quotes
8 purchase
9 test
10 achromatic design
11 half-wave plate
12 rotation mechanism design
13 rotation mechanism manufa
14 temperature controller desig
15 temperature controller manu
16 Polarization compensator
17 specifications
18 mechanical design
19 mechanical fabrication
20 Polarizing Beamsplitter
21 specifications
22 optical design
23 purchase beamsplitter
24 purchase prisms
25 mechanical design
26 mechanical fabrication
27 AIT
28 Polarization calibration
29 requirements
30 design
Christoph Keller[20%]
Michiel Rodenhuis[80%]
SI Mechanical Design
SI Mechanical Manufacturing
SI Electronic Design
SI Electronic Manufacturing
Michiel Rodenhuis[40%]

Work Smarter, Not Harder?

- Sponsors may assume that ‘padding’ is in plan
- Get pushed to do things faster, cheaper, and better
- But plan is based on careful analysis and established planning approaches
- Try to resolve discrepant views and have
  1. Convinced sponsor and have support for plan
  2. Adjust plan based on helpful insights
  3. If you agree to the impossible, it will still remain impossible

Cash Flow Plan

- Determine when money is going to be spent
- Requires both cost estimates and schedule
- Can be easily calculated
- Often an issue in scientific projects because funding agencies will only provide equal payments per period
- Project sponsor may have to play the bank

Cash Flow Plan Example

	Year 1	Year 2	Year 3	Year 4	Year 5
Personnel					
Postdoc (5 years ,vacant)	55000	55000	55000	55000	55000
PhD student A (4 years, vacant)	38000	39000	39500	40000	0
PhD student B (4 years, vacant)	0	38000	39500	40000	39000
Equipment etc.					
Equipment	112000	86000	83000	16000	5000
Consumables	5000	5000	5000	5000	5000
Workshop/Conference	0	0	35000	0	0
Travel	10000	10000	10000	10000	10000
Cash Needed	220000	233000	267000	166000	114000
Cash Available	189200	189200	189200	189200	189200
Cash Needed - Available	**30800**	**43800**	**77800**	**-23200**	**-75200**

Final Remarks

- Accurate estimates take time and cost money
- Lessons of the past improve forecasts of the future
- Compare estimates with actual performance to improve future estimates
- Know when to use which method
- Know how much accuracy is required for a certain decision
- Forces outside of project control often responsible for wrong estimates